CERTIFICATION OF TRANSLATION

I, ***Sung-mi Park*** , an employee of Y.P. LEE, MOCK & PARTNERS of The Cheonghwa Bldg., 1571-18 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare under penalty of perjury that I understand the Korean language and the English language; that I am fully capable of translating from Korean to English and vice versa; and that, to the best of my knowledge and belief, the statement in the English language in the attached translation of ***Korean Patent Application No. 10-2000-0039091*** consisting of 29 pages, have the same meanings as the statements in the Korean language in the original document, a copy of which I have examined.

Signed this 27th day of September 2005

Sung-mi Park

ABSTRACT

[Abstract of the Disclosure]

A compatible optical pickup device includes a single light source for emitting light having a wavelength longer than 650 nm, an objective lens formed of a near axis area, a ring type annular lens area, and a far axis area with respect to an apex for focusing light emitted from the light source to form light spots suitable for a first optical disk which is relatively thin and a second optical disk which is relatively thick, so as to form a light spot having an FWHM (full width at half maximum) less than or equal to 0.72 μm with respect to the first optical disk and a light spot having an FWHM greater than or equal to 0.8 μm with respect to the second optical disk, an optical path changer arranged on the optical path between the light source and the objective lens for changing a proceeding path of incident light, and a photodetector for receiving light reflected by the optical disk and passing through the objective lens and the optical path changer and detecting an information signal and/or error signal. Thus, since the compatible optical pickup device according to the present invention includes an inexpensive single light source for emitting light a wavelength longer than 650 nm and an objective lens, designed in relation to the wavelength of the light emitted from the light source, for forming a light spot having an FWHM equal to or less than 0.72 μm with respect to an optical disk of a DVD family and a light spot having an FWHM greater than or equal to 0.8 μm with respect to an optical disk of a CD family, it has an inexpensive and simple structure and can compatibly reproduce/record an optical disk of a CD or DVD family.

[Representative Drawing]

FIG. 2

SPECIFICATION

[Title of the Invention]

Compatible optical pickup device adopting single light source

[Brief Description of the Drawings]

FIG. 1 is a view showing the optical arrangement of an example of a conventional compatible optical pickup device;

FIG. 2 is a view showing the optical arrangement of a compatible optical pickup device adopting a single light source according to a preferred embodiment of the present invention;

FIG. 3 is a plan view of the objective lens according to the present invention of FIG. 2;

FIGS. 4 and 5 are views showing examples of the objective lens according to the present invention each being adopted in FIG. 2;

FIG. 6 is a view showing the optical arrangement of a compatible optical pickup device adopting a single light source according to another preferred embodiment of the present invention;

FIG. 7 is a view showing the optical arrangement of a compatible optical pickup device adopting a single light source according to yet another preferred embodiment of the present invention;

FIGS. 8A and 8B are graphs indicating an aberration characteristic according to the field of an incident beam between the objective lens of the present invention and the conventional 650 nm objective lens;

FIGS. 9A and 9B are graphs indicating an aberration characteristic according to the tilt of an optical disk between the objective lens of the present invention and the conventional 650 nm objective lens; and

FIG. 10 is a graph showing a reproduction signal value according to the depth of a pit when a DVD is reproduced by the compatible optical pickup device according to the present invention.

< Explanation of Reference numerals designating the Major Elements of the Drawings >

40....	Optical disk	40a, 40b....	First and second optical disks
50....	Light source	60....	Holographic beam splitter

63, 163....	Wave plate	70....	Objective lens
71, 75.....	near and far axis areas	73...	Ring type annular lens area

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art prior to the Invention]

The present invention relates to a compatible optical pickup device which can compatibly read/write optical disks of the CD family or DVD family, and more particularly, to a compatible optical pickup device adopting a single light source for emitting light having a wavelength longer than 650 nm.

A typical optical pickup device reproduces and records information on and/or from a recording medium in a non-contact manner. An optical pickup device capable of performing reproducing/recording of optical disks of the DVD family having a thickness of 0.6 mm (hereinafter referred to as "DVD") adopts an objective lens having a numerical aperture of 0.6 and a light source for emitting light having a 650 nm wavelength. Here, the optical pickup device for DVD should be compatible with optical disks of a CD family which is 1.2 mm thick (hereinafter referred to as "CD").

In consideration of the above matter, optical pickup devices which can compatibly reproduce/record optical disks in different formats have been suggested. A conventional optical pickup which can compatibly reproduce/record a CD and a DVD, as shown in FIG. 1, has the structure adopting two light sources 1 and 3 for emitting light having different wavelengths.

Referring to FIG. 1, a first light source 1 emits light having 635 or 650 nm to reproduce/record a DVD 10a which is relatively thin. A second light source 3 emits light having a 780 nm wavelength to reproduce/record a CD 10b which is relatively thick. The light emitted from the first light source 1 passes through a first beam splitter 7 and is reflected by a second beam splitter 9 so as to proceed toward an optical disk 10. The light emitted from the second light source 3 is sequentially reflected by the first and second beam splitters 7 and 9 and proceeds toward the optical disk 10. An objective lens 15 focuses incident light output from the first and second light sources 1 and 3 to form a light spot. Here, the light emitted from the first light source 1 is focused on the relatively thin DVD 10a while the light emitted from the second light source 3 is focused on the relatively thick CD 10b.

The light reflected by the disk 10 is incident on the second beam splitter via the objective lens 15. Most of the light passes through the second beam splitter 9

and is received by a photodetector 19. Here, reference numeral 5 denotes a grating for diffracting and splitting the light output from the second light source 3 into the 0^{th} order and the $\pm 1^{st}$ order rays to detect a tracking error signal by a three-beam method during reproducing/recording of the CD 10b. Reference numeral 11 denotes a collimating lens for converting the divergent light output from the first and second light sources 1 and 3 into a parallel beam. Reference numeral 17 denotes a sending lens 17 for focusing the incident light reflected by the disk 10 and passing through the second beam splitter 9 so that the light can be received by the photodetector 19.

Since the conventional compatible optical pickup device having the above structure includes two light sources 1 and 3 emitting light having different wavelengths, optical disks of both the CD family and DVD family can be reproduced/recorded.

However, since the conventional compatible optical pickup device adopts two separate light sources, a cost of manufacturing is high and the structure thereof is complicated, and further, assembly and optical arrangement is difficult. Further, the light source 1 for a 635 or 650 nm wavelength which can emit recording power for DVD-R and/or DVD-RAM is expensive, which prevents reduction of the entire cost of a compatible optical pickup device.

[Technical Goal of the Invention]

To solve the above problems, it is an object of the present invention to provide an inexpensive compatible optical pickup device adopting a single light source for emitting light having a wavelength longer than 650 nm so that an optical disk of the CD family and DVD family can be compatibly reproduced/recorded.

[Structure and Operation of the Invention]

To achieve the above object, there is provided a compatible optical pickup device comprising a single light source for emitting light having a wavelength longer than 650 nm, an objective lens formed of a near axis area, a ring type annular lens area, and a far axis area with respect to an apex for focusing light emitted from the light source to form light spots suitable for a first optical disk which is relatively thin and a second optical disk which is relatively thick, so as to form a light spot having an FWHM (full width at half maximum) of 0.72 μm or less with respect to the first optical disk and a light spot having an FWHM greater than or equal to 0.8 μm with respect to the second optical disk, an optical path changer arranged on the optical

path between the light source and the objective lens for changing a proceeding path of incident light, and a photodetector for receiving light reflected by the optical disk and passing through the objective lens and the optical path changer and detecting an information signal and/or error signal.

It is preferred in the present invention that the first optical disk is an optical disk of a DVD family and the second optical disk is an optical disk of a CD family.

It is preferred in the present invention that the light source emits light having a wavelength between 680 - 780 nm.

It is preferred in the present invention that the annular lens area of the objective lens is optimized to the second optical disk so that, when the first optical disk is to be reproduced/recorded, a light spot of light passing through the near axis area and the far axis area is focused on the information recording surface of the first optical disk, while, when the second optical disk is to be reproduced/recorded, a light spot of light passing through the near axis area and the annular lens area is focused on the information recording surface of the second optical disk.

It is preferred in the present invention that the light source is an edge emitting laser or a vertical cavity surface emitting laser, and the optical path changer comprises a polarization hologram element for diffracting incident light to the 0^{th} order ray, or $+1^{st}$ order and/or -1^{st} order rays according to a linear polarization component thereof, and a wave plate for changing the polarization of the incident light.

Here, the optical path changer may comprise a beam splitter arranged between the light source and the objective lens for transmitting and/or reflecting incident light. When the beam splitter transmit or reflect incident light according to polarization of the incident light, a wave plate for changing the polarization of the incident light is further provided between the beam splitter and the objective lens.

Preferred embodiments of the present invention will now be described with reference to the attached drawings.

Referring to FIG. 2, a compatible optical pickup device according to a preferred embodiment of the present invention includes a single light source 50 for emitting light having a wavelength longer than 650 nm, an objective lens 70 mounted and driven on an actuator (not shown) for focusing and tracking controls for forming a light spot suitable for each of the first and second optical disks 40a and 40b having different thicknesses by focusing the light output from the light source 50, an optical path changer disposed on an optical path between the light source 50 and the

objective lens 70 for changing a proceeding path of the incident light, and a photodetector 100 for receiving the light reflected by an optical disk 40. Here, the first optical disk 40a is an optical disk of the DVD family which is relatively thin and the second optical disk 40b is an optical disk of the CD family which is relatively thick.

Preferably, a semiconductor laser for emitting light of a high optical power, that is, an edge emitting laser or a vertical cavity surface emitting laser, to be used not only for reproducing information signals but also for recording information signals, is provided as the light source 50. The light source 50 emits light having a wavelength longer than 650 nm, for example, a wavelength between 660 nm through 790 nm. Here, the light source 50 preferably emits light having a wavelength between 680 nm through 780 nm.

Here, with respect to a recording optical power for a DVD-R and/or DVD-RAM, the unit cost of production of a semiconductor laser for a wavelength longer than 650 nm is much lower than that of a semiconductor laser for a 650 nm wavelength. Thus, according to the present invention, the unit cost of production of the light source 50 can be drastically reduced. For example, when a 680 nm semiconductor laser is adopted as the light source 50, since the unit cost of production of the 680 nm semiconductor laser is much lower than a 650 nm semiconductor laser adopted as a general light source for DVD, the unit cost of production of the compatible optical pickup device according to the present invention can be drastically reduced.

When a semiconductor laser for emitting light having a wavelength over 750 nm is adopted as the light source 50, the cost of the compatible optical pickup device according to the present invention can be much low and simultaneously a CD-R which is currently commercialized can be compatibly reproduced/recorded. Here, since the currently commercialized CD-R has an organic pigment film recording layer having a large absorptivity with respect to light having a wavelength less than 750 nm, in order to reproduce/record the CD-R, a light source for emitting light having a wavelength equal to or greater than 750 nm to prevent destruction of recording data due to a difference in sensitivity, is needed. Of course, if the CD-R is manufactured to have a small absorptivity with respect to the light having a wavelength equal to or less than 750 nm, the compatible optical pickup device according to the present invention can compatibly reproduce/record CD-Rs regardless of a wavelength range of the adopted light source 50.

Meanwhile, when a semiconductor laser is provided as the light source 50, the light source 50 emits linearly polarized light approximately in one direction. Thus, it is preferable to include a holographic beam splitter 60 consisting of a polarization hologram element 61 for diffracting incident light into the 0^{th} order ray, or the $+1^{st}$ order and/or the -1^{st} order rays according to a linear polarization component and a wave plate 63 for converting the polarization of the incident light. In this case, most of the light emitted from the light source 50 proceeds toward the optical disk 40 while most of the light reflected by the optical disk 40 is received by the photodetector 100, so that the efficiency in use of light is high.

The polarization hologram element 61 is preferably arranged to diffract the light output from the light source 50 and linearly polarized in one direction into the 0^{th} order ray. Preferably, a quarter wave plate with respect to the wavelength of the light emitted from the light source 50 is provided as the wave plate 63 and arranged to convert the linearly polarized light output from the light source 50 to a circularly polarized light.

Thus, the light output from the light source 50 and linearly polarized light in one direction is diffracted into the 0^{th} order ray by the polarization hologram element 61, converted to one circularly polarized light while passing through the wave plate 63, and focused on the information recording surface of the optical disk 40 by the objective lens 70. The focused light is reflected by the information recording surface of the optical disk 40 and converted to another circularly polarized light. The other circularly polarized light is converted to light linearly polarized in other direction while passing through the wave plate 63 and diffracted into the $+1^{st}$ order and/or -1^{st} order rays by the polarization hologram element 61 and proceeds toward the photodetector 100.

The photodetector 100 receives light reflected by the optical disk 40 and passing through the objective lens 70 and the holographic beam splitter 60 and detects information signal and/or error signal. The photodetector 100 includes a plurality of sectional plates (not shown) each independently performing photoelectric conversion.

When the holographic beam splitter 60 is provided as the optical path changer, since the photodetector 100, as shown in FIG. 2, can be installed on a base 101 where the light source 50 is installed, the photodetector 100 and the light source 50 can be modularized. Here, as the holographic beam splitter 60, a holographic

device (not shown) may be provided by which most of the light output from the light source 50 is diffracted into the 0^{th} order ray and most of the light output from the optical disk 40 is diffracted into the $+1^{st}$ order and/or -1^{st} order ray.

Here, reference numeral 65 denotes a collimating lens for forming an indefinite optical system by changing the divergent light output from the light source 50 to a parallel light. The collimating lens 65 is preferably arranged between the optical path changer and the objective lens 70. In this case, the collimating lens 65 converts the divergent light output from the light source 50 to a parallel light and simultaneously the light reflected by the optical disk 40 and incident thereon to a focused light to proceed toward the photodetector 100.

The objective lens 70, as shown in FIG. 3, consists of a near axis area 71, a ring type annular lens area 73 and a far axis area 75 with respect to an apex. Here, the apex is a point where the central axis of the objective lens 70 and the surface of the objective lens 70 meet. The annular lens area 73 is an area on which light of an intermediary area between the near axis area 71 and the far axis area 75 is incident, which is formed to be an oval ring or circular ring type on the surface of the objective lens 70 facing the light source 50 or the recording medium 40.

According to a preferred embodiment of the present invention, the annular lens area 73 is formed to be aspherical as shown in FIG. 4 and is preferably optimized with respect to the relatively thick second optical disk 40b.

If the annular lens area 71 has an aspherical shape optimized with respect to the second optical disk 40b, when the relatively thin first optical disk 40a is to be reproduced/recorded, the light emitted from the light source 50 and passes through the near axis area 71 and the far axis area 75 is focused on the information recording surface of the first optical disk 40a. The light emitted from the light source 50 and passes through the annular lens area 73 between the near axis area 71 and the far axis area 75 is so spread that information cannot be reproduced from the information recording surface of the first optical disk 40a.

When the second optical disk 40b is used, of the light emitted from the light source 50, the light passing through the near axis area 71 and the annular lens area 73 is focused on the information recording surface of the second optical disk 40b as a light spot, while the light passing through the far axis area 75 is so spread so that it cannot be used to reproduce information from the information recording surface of the second optical disk 40b.

Alternatively, the annular lens area 73, as shown in FIG. 7, can be formed to shield or scatter incident light. In this case, when the first optical disk 40a is used, of the light emitted from the light source 50, the light passing through the near axis area 71 and the far axis area 75 is focused on the information recording surface of the first optical disk 40a as a light spot, while the light passing through the annular lens area 73 is shielded or scattered so that it cannot be focused on the information recording surface of the first optical disk 40b. Also, when the second optical disk 40abis used, of the light emitted from the light source 50, the light passing through the near axis area 71 is focused on the information recording surface of the second optical disk 40b as a light spot. In contrast, the light passing the far axis area 75 is not focused on the information recording surface of the second optical disk 40b with an intensity suitable for reproducing and/or recording, while the light passing through the annular lens area 73 is shielded or scattered so that it is not focused on the information recording surface of the second optical disk 40b.

The objective lens 70 having the structure according to the present invention is provided to focus the light output from the light source 50 so that a light spot suitable for each of the first and second optical disks 40a and 40b having difference thicknesses can be formed. That is, the objective lens 70 according to the present invention preferably forms a light spot having an FWHM (full with at half maximum) equal to or less than 0.72 μm (a width which is equal to or less than 1.2 μm at $1/e^2$) with respect to the first optical disk 40a, and a light spot having an FWHM equal to or greater than 0.8 μm (a width which is equal to or greater than 1.3 μm at $1/e^2$) with respect to the second optical disk 40b.

In order to form a light spot having the above size, the objective lens 70 has a numerical aperture related to the wavelength of the light emitted from the light source 50. That is, when the light source 50 emits light having a wavelength between 680 - 780 nm, the objective lens 70 has an effective numerical aperture of greater than or equal to 0.63 with respect to the first optical disk 40a and an effective numerical aperture less than or equal to 0.53 with respect to the second optical disk 40b. When the light source 50 emits light having a 780 nm wavelength, the objective lens 70 preferably has an effective numerical aperture greater than or equal to 0.7 with respect to the first optical disk 40a and an effective numerical aperture less than or equal to 0.53 with respect to the second optical disk 40b.

As a detailed example, when the light source 50 emits light having a wavelength of 680 nm, 720 nm, or 780 nm, the objective lens 70 preferably has an effective numerical aperture of about 0.63, 0.66, or 0.72 with respect to the first optical disk 40a.

Here, FIG. 2 shows a case in which the objective lens 70 having the annular lens area 73 having an aspherical shape described with reference to FIG. 4 is adopted. In particular, in FIG. 2, the objective lens 70 is schematically illustrated to show the focus of the light according to the incident areas.

Also, in FIGS. 2, 4 and 5, the light incident surface of the second optical disk 40b is disposed close to the objective lens 70 than the light incident surface of the first optical disk 40a. This is to show a difference in distance between the objective lens 70 and the light incident surface of the first optical disk 40a and distance between the objective lens 70 and the light incident surface of the second optical disk 40b, that is, a working distance difference. In an actual system, the light incident surfaces of the first and second optical disks are located at the same position, and when the second optical disk 40b is used, the objective lens 70 is driven by an actuator and is moved closer to the second optical disk 40b than in the first optical disk 40a to be suitable for the working distance.

The compatible optical pickup device according to the present invention, as shown in FIGS. 6 and 7, may include a beam splitter type optical path changer. That is, as the optical path changer, as shown in FIG. 6, a polarizing beam splitter 161 disposed between the light source 50 and the objective lens 70 for transmitting or reflecting incident light according to polarization and a wave plate 163 disposed between the polarizing beam splitter 161 and the objective lens 70 for converting polarization of incident light may be provided. Also, as the optical path changer, as shown in FIG. 7, a beam splitter 260 disposed between the light source 50 and the objective lens 70 for transmitting and reflecting incident light in a predetermined ratio may be provided.

When the above beam splitter type optical path changer is provided, a sensing lens 167 disposed on the optical path between the optical path changer and the photodetector 100 for focusing incident light so that it can be received by the photodetector 100, is further provided.

In addition, the compatible optical pickup device according to the present invention, as shown in FIG. 7, further includes a diffraction element 250 disposed between the light source 50 and the optical path changer for diffracting the light

emitted from the light source 50. The diffraction element 250 is used to detect a DPP (differential push-pull) signal for tracking when a DVD-RAM is reproduced, or a tracking signal in a three beams method when a CD is reproduced. The two diffraction element 250 may be provided for the reproduction of each of a DVD-RAM and a CD. The diffraction element 250 may be applied to the compatible optical pickup device shown in FIGS. 2 and 6.

Since the remaining members of FIGS. 4 and 7 are the same as those described with reference to FIG. 2, the same reference numerals are used therefor and detailed descriptions thereof will be omitted.

The compatible optical pickup device according to the present invention is not limited to the optical configuration as shown in FIGS. 2, 6 and 7, and of course, a variety of modifications thereto are possible.

Since the compatible optical pickup devices according to the preferred embodiments of the present invention adopt a single light source 50 for emitting light having a wavelength longer than 650 nm, preferably, a wavelength between 680 nm through 780 nm, a cost for the system can be lowered. Also, since the compatible optical pickup device according to the present invention includes an objective lens 70 designed to have an effective numeral aperture suitable for the first and second optical disks 40a and 40b in relation to the wavelength of the light emitted from the single light source 50, a light spot having an FWHM equal to or less than 0.72 μm is formed with respect to the first optical disk 40a while a light spot having an FWHM greater than or equal to 0.8 μm is formed with respect to the second optical disk 40b. Thus, the compatible optical pickup device according to the present invention can compatibly reproduce/record the first and second optical disks 40a and 40b having different thicknesses. Of course, when a light source for emitting light having a wavelength greater than or equal to 750 nm is adopted as the light source 50, recording/reproduction of a presently commercialized CD-R and DVD-R is possible

With reference to Table 1 and FIGS. 8A, 8B, 9A and 9B, properties of the objective lens 70 according to the present invention which is designed to compatibly reproduce/record the first and second optical disks 40a and 40b with respect to a 780 nm wavelength and a conventional objective lens for a DVD with respect to a 650 nm wavelength (not shown; hereinafter referred to as an objective lens for 650 nm) are compared with each other.

Table 1 shows data values of the objective lens 70 of the present invention with respect to the first optical disk 40a, that is, an example of design values for a DVD. The working distance is a distance between the surface of the objective lens 70 facing the optical disk 40 and the surface of the optical disk 40 on which light is incident. When the second optical disk 40b, that is, a CD, is reproduced/recorded, the working distance is reduced by 0.3 mm. The aberration properties in the case of a DVD are shown in FIGS. 8A through 9B. A value of 0.04λ indicated by dotted lines of FIG. 8A

through 9B is allowable optical aberration (OPDrms) with respect to a DVD in the optical disk system.

[Table 1]

	Objective Lens (present invention)	Objective Lens (conventional)	Remarks
NA	0.73	0.61	
Working Distance (mm)	1.3	1.8	Reduced by 0.3 mm in the case of CD
Effective Diameter (mm)	4.09	4.03	
Focal Distance (mm)	2.8	3.3	
Maximum Angle of Curved Surface of Lens	55°	51°	Possible to manufacture
OPDrms at Field Height of 1.0°	0.033λ	0.060λ	
OPDrms at Optical Disk Tilt of 0.35°	0.041λ	0.038λ	Allowable Optical Disk Tilt: 0.35°

Referring to Table 1, the objective lens for 650 nm has a numerical aperture of 0.61 while the objective lens 70 of the present invention is designed to have a numerical aperture of 0.73. That is, the objective lens 70 for 780 nm of the present invention has numerical aperture greater than the conventional objective lens for 650 nm. While the objective lens for 650 nm has a working distance of 1.8 mm, the objective lens 70 of the

present invention has a working distance of 1.3 mm. Of course, when a CD is to be reproduced/recorded, the working distance is reduced by 0.3 mm as shown in FIGS. 2, and 4 through 7. The effective diameter of the objective lens for 650 nm is 4.03 mm and the focal distance is 3.3 mm, while the objective lens 70 of the present invention has an effective diameter of 4.09 mm and a focal distance of 2.8 mm. While the maximum angle of the curved surface of the objective lens for 650 nm is 51°, the objective lens 70 of the present invention is manufactured to have the maximum angle of the curved surface of 55°. The above maximum angle is a value which can be manufactured.

Referring to FIGS. 8A and 8B showing aberration properties according to incident beam fields of the objective lens 70 of the present invention and the objective lens for 650 nm designed according to the data of Table 1, the objective lens for 650 nm shows an OPDrms of 0.06λ with respect to a field height of 1.0°, while the objective lens 70 of the present invention shows an OPDrms of 0.033λ, exhibiting a superior field aberration than that of the objective lens for 650 nm. Here, field aberration is generated when the light emitted from the light source is incident on the objective lens at an inclined angle. Thus, a objective lens preferably has field aberration equal to or less than 0.04λ which is an allowable optical aberration value, with respect to a field height of 1° considering allowance in assembly of the optical pickup device.

Referring to FIGS. 9A and 9B showing aberration properties according to inclination of the optical disk 40 of the objective lens 70 of the present invention and the objective lens for 650 nm designed according to the data of Table 1, with respect to the tile of the optical disk 40 in which an allowable tilt angle of an optical disk system is 0.35°, the objective lens 70 of the present invention shows OPDrms of 0.041λ which is similar to the OPDrms of 0.038λ of the objective lens for 650 nm.

As can be seen from the above, when a DVD is reproduced/recorded, the objective lens 70 of the present invention designed with respect to 780 nm exhibits a aberration property which is similar to or superior to the conventional objective lens for a DVD designed with respect to 650 nm. Also, the objective lens 70 of the present

invention has a numerical aperture greater than that of the conventional objective lens for a DVD. Accordingly, even when light having a wavelength greater than 650 nm is used, a light spot having a small size suitable for reproducing/recording a DVD can be formed. Thus, in a compatible optical pickup device adopting a single light source for a wavelength longer than 650 nm according to the present invention can compatibly reproduce/record not only the second optical disk 40b of a CD family but also the optical disk 40 of a DVD family.

Here, the size of a light spot is proportional to λ/NA (λ is a wavelength and NA is the numerical aperture of the objective lens 70). Thus, since the objective lens 70 of the present invention has numerical aperture greater than a typical objective lens for a DVD, even when light having a wavelength longer than 650 nm is used, a small light spot needed to reproduce/record the first optical disk 40a of a DVD family can be formed.

FIG. 10 shows values of reproduction signals according to the depth of a pit when a DVD is reproduced by a compatible optical pickup device according to the present invention. In FIG. 8, the reproduction signals are obtained with respect to values of reproduction signals detected when a DVD having a pit of which the depth is λ/6 is reproduced by a conventional DVD dedicated apparatus. As shown in FIG. 10, for example, when the 780 nm light source 50 and the objective lens 70 having numerical aperture greater than that of the conventional objective lens for 650 nm with respect to a DVD are adopted, in the case in which the depth of a pit of a DVD is λ/6, since about 90% of the amplitude of the signal can be detected compared to the signal by the conventional DVD dedicated apparatus, a DVD can be reproduced.

[Effect of the Invention]

As described above, since the compatible optical pickup device according to the present invention includes an inexpensive single light source for emitting light a wavelength longer than 650 nm and an objective lens, designed in relation to the wavelength of the light emitted from the light source, for forming a light spot having an FWHM equal to or less than 0.72 μm with respect to an optical disk of a DVD family and

a light spot having an FWHM greater than or equal to 0.8 μm with respect to an optical disk of a CD family, it has an inexpensive and simple structure and can compatibly reproduce/record an optical disk of a CD or DVD family.

What is claimed is:

1. A compatible optical pickup device comprising:

a single light source for emitting light having a wavelength longer than 650 nm;

an objective lens formed of a near axis area, a ring type annular lens area, and a far axis area with respect to an apex for focusing light emitted from the light source to form light spots suitable for a first optical disk which is relatively thin and a second optical disk which is relatively thick, so as to form a light spot having an FWHM (full width at half maximum) less than or equal to 0.72 μm with respect to the first optical disk and a light spot having an FWHM greater than or equal to 0.8 μm with respect to the second optical disk;

an optical path changer arranged on the optical path between the light source and the objective lens for changing a proceeding path of incident light; and

a photodetector for receiving light reflected by the optical disk and passing through the objective lens and the optical path changer and detecting an information signal and/or error signal.

2. The device as claimed in claim 1, wherein the first optical disk is an optical disk of a DVD family and the second optical disk is an optical disk of a CD family.

3. The device as claimed in claim 1, wherein the light source emits light having a wavelength between 680 - 780 nm.

4. The device as claimed in one of claims 1 and 2, wherein the objective lens has an effective numerical aperture greater than or equal to 0.7 with respect to the first optical disk which is relatively thin.

5. The device as claimed in one of claims 1 and 2, wherein the annular lens area of the objective lens is optimized to the second optical disk so that, when the first optical disk is to be reproduced/recorded, a light spot of light passing through the near

axis area and the far axis area is focused on the information recording surface of the first optical disk, while, when the second optical disk is to be reproduced/recorded, a light spot of light passing through the near axis area and the annular lens area is focused on the information recording surface of the second optical disk.

6. The device as claimed in one of claims 1 and 2, wherein the annular lens area of the objective lens is optimized to the second optical disk so that, when the first optical disk is to be reproduced/recorded, a light spot of light passing through the near axis area and the far axis area is focused on the information recording surface of the first optical disk, while, when the second optical disk is to be reproduced/recorded, a light spot of light passing through the near axis area and the annular lens area is focused on the information recording surface of the second optical disk.

7. The device as claimed in claim 1, wherein the light source is an edge emitting laser or a vertical cavity surface emitting laser, and the optical path changer comprises:

a polarization hologram element for diffracting incident light to the 0^{th} order ray, or $+1^{st}$ order and/or -1^{st} order rays according to a linear polarization component thereof; and

a wave plate for changing the polarization of the incident light.

8. The device as claimed in claim 1, wherein the light source is an edge emitting laser or a vertical cavity surface emitting laser, and the optical path changer comprises a beam splitter arranged between the light source and the objective lens for transmitting and/or reflecting incident light.

9. The device as claimed in claim 8, wherein the beam splitter is provided to transmit or reflect incident light according to polarization of the incident light, and the device further comprises a wave plate arranged between the beam splitter and the

objective lens for changing the polarization of the incident light.

10. The device as claimed in one of claims 1, and 7 through 9, further comprising a collimating lens on an optical path between the optical path changer and the objective lens.

FIG. 1

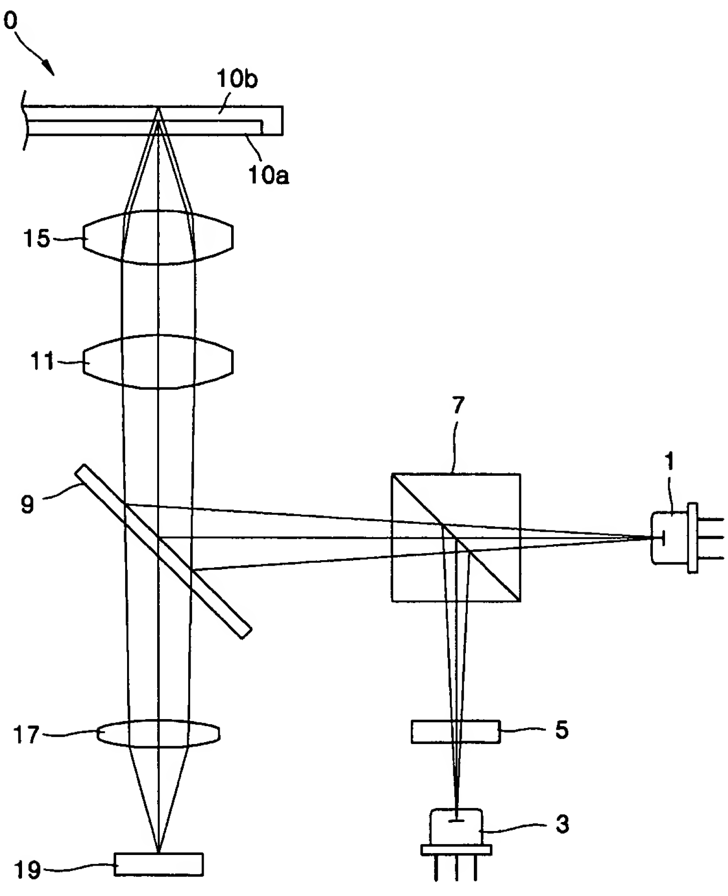


FIG. 2

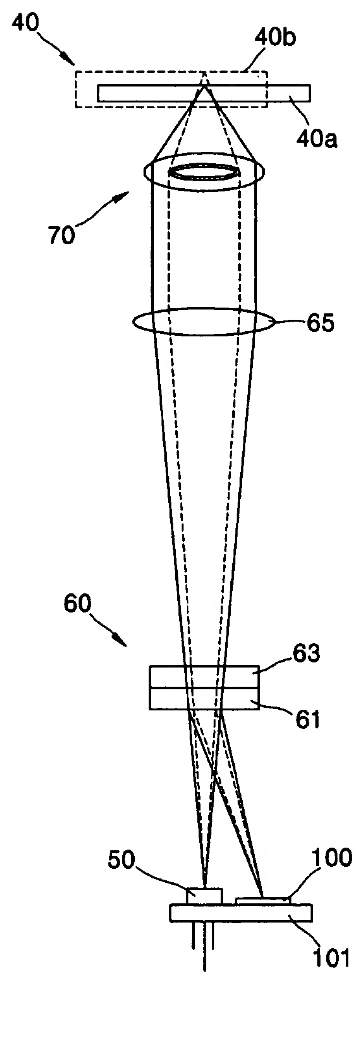


FIG. 3

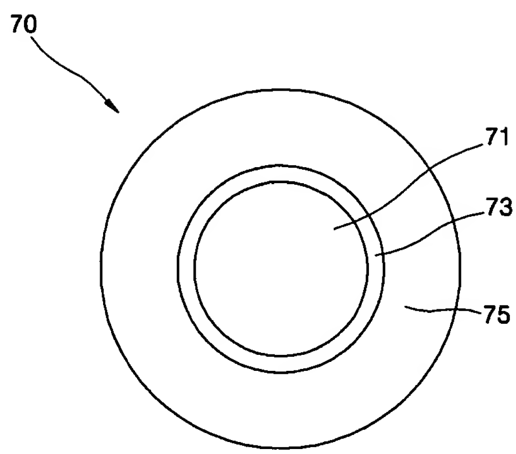


FIG. 4

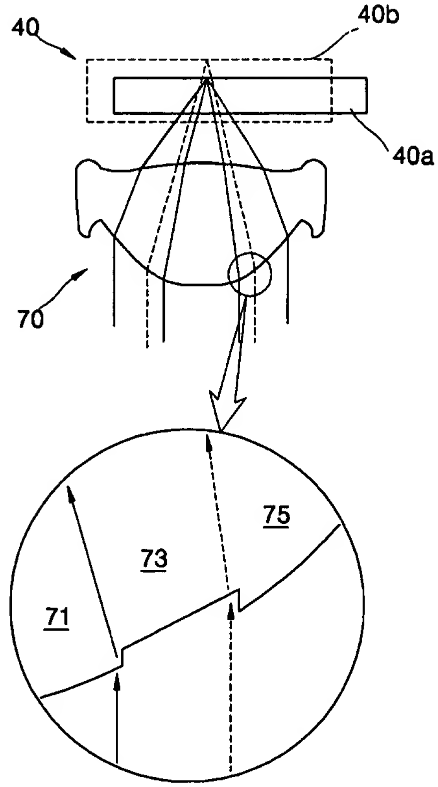


FIG. 5

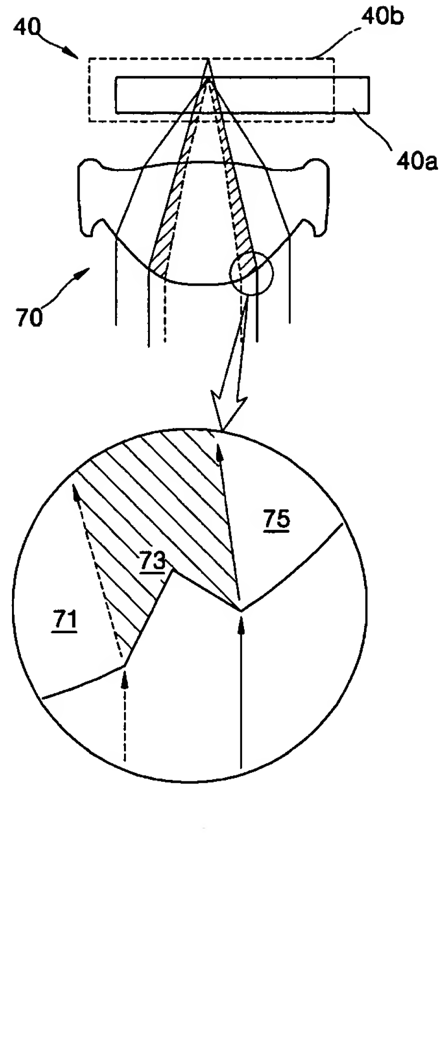


FIG. 6

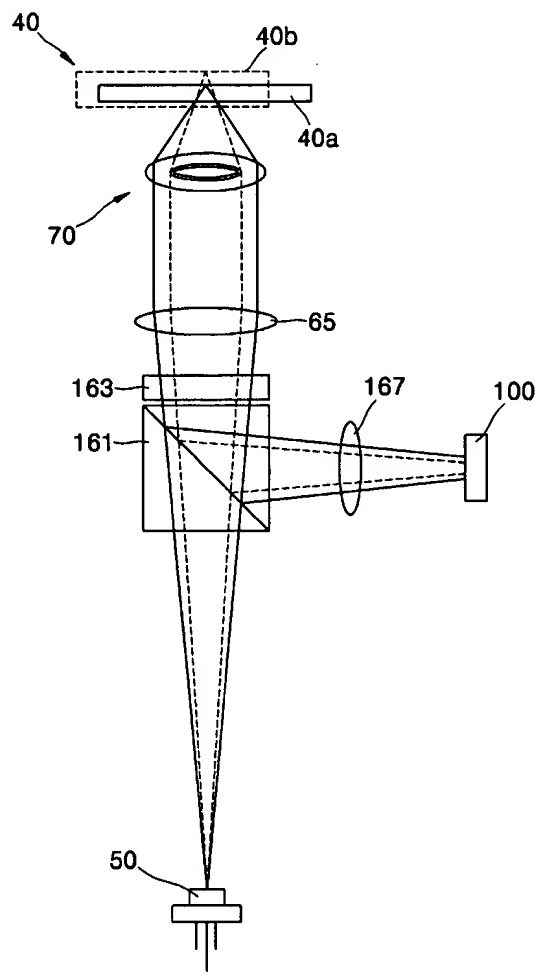


FIG. 7

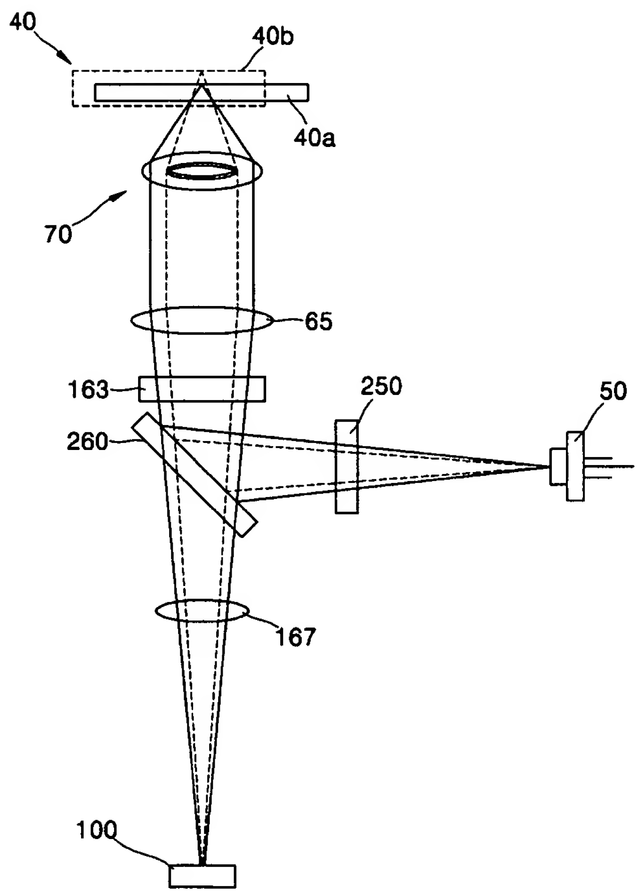


FIG. 8A

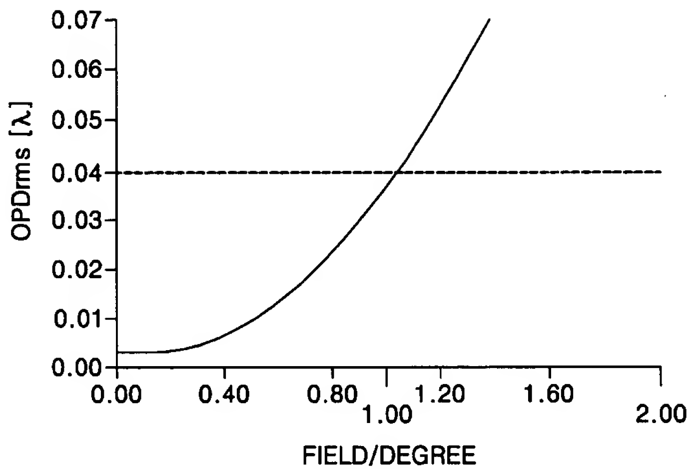

0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
OPDrms [λ]
0.00
0.40
0.80
1.00
1.20
1.60
2.00
FIELD/DEGREE

FIG. 8B

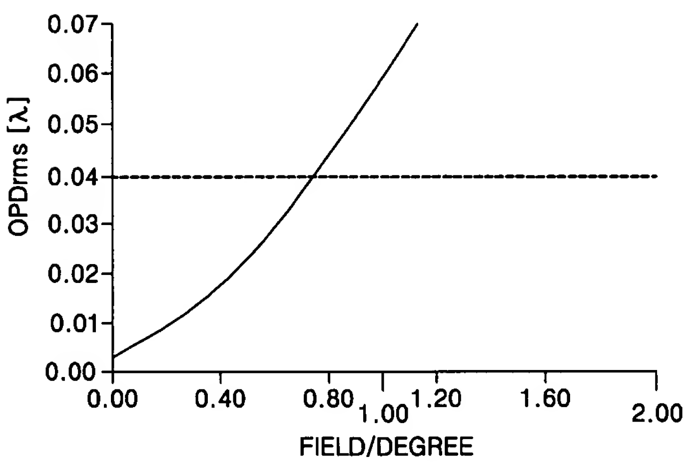

0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
OPDrms [λ]
0.00
0.40
0.80
1.00
1.20
1.60
2.00
FIELD/DEGREE

FIG. 9A

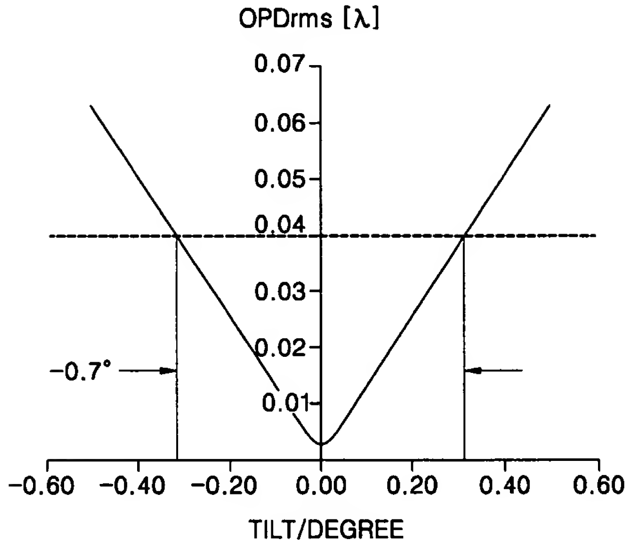

OPDrms [λ]
0.07
0.06
0.05
0.04
0.03
0.02
0.01
−0.7°
−0.60
−0.40
−0.20
0.00
0.20
0.40
0.60
TILT/DEGREE

FIG. 9B

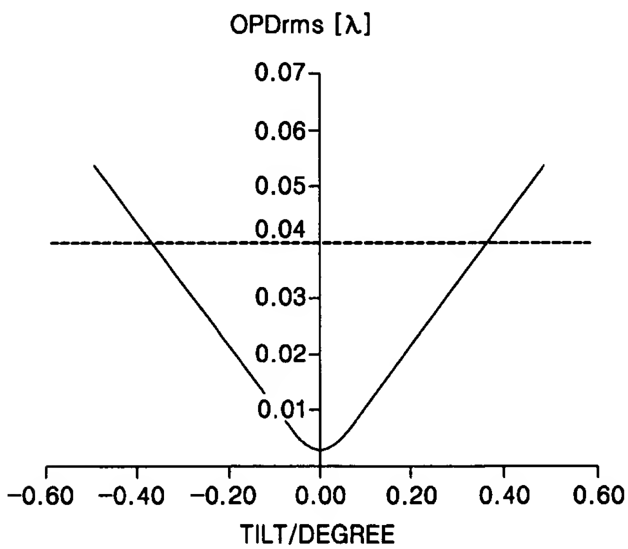
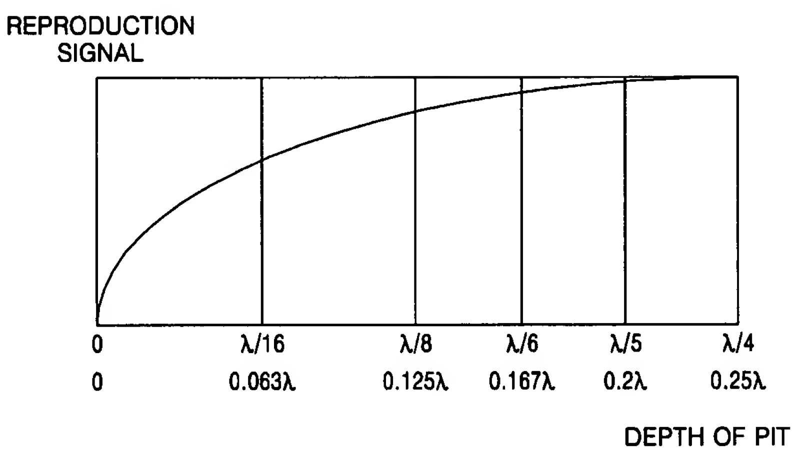

OPDrms [λ]
0.07
0.06
0.05
0.04
0.03
0.02
0.01
−0.60
−0.40
−0.20
0.00
0.20
0.40
0.60
TILT/DEGREE

FIG. 10



REPRODUCTION
SIGNAL
0
λ/16
λ/8
λ/6
λ/5
λ/4
0
0.063λ
0.125λ
0.167λ
0.2λ
0.25λ
DEPTH OF PIT